1248985

PATENT SPECIFICATION

(11) 1248985

NO DRAWINGS

(21) Application No. 60775/68 (22) Filed 20 Dec. 1968

(31) Convention Application No. 17574 (32) Filed 21 Dec. 1967 in

(33) Sweden (SW)

(45) Complete Specification published 6 Oct. 1971

(51) International Classification C 22 c 39/26

(52) Index at acceptance

C7A 711 745 746 771 78Y A249 A253 A255 A257 A25Y A28X A28Y A30Y A311 A313 A316 A319 A320 A323 A339 A349 A35Y A360 A389 A409 A41Y A428 A432 A435 A437 A43X A459 A509 A529 A53Y A545 A547 A55Y A579 A584 A587 A589 A58Y A591 A593 A59X A601 A603 A605 A60Y A617 A619 A61Y A621 A623 A625 A62X A671 A673 A675 A677 A679 A67X A681 A683 A684 A685 A687 A689 A68X A693 A695 A696 A697 A698 A699 A69X A70X

B3R 32G 36 37A1A 37A1C 37A1D

(54) IMPROVEMENTS IN WELDING ELECTRODE

(71) We, AVESTA JERNVERKS AKTIEBOLAG, a Swedish Joint-Stock Company, of Avesta, Sweden, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a welding electrode for electric arc welding.

Certain types of stainless steels particularly steels with a ferrite-martensitic, ferrite-martensite-austenitic or martensite-austenitic structure, obtain high mechanical strength characteristics, partly owing to their chemical composition and partly by the heat treatment they undergo prior to being used. Austenitic stainless steels in a heat-treated condition, on the other hand, have a low yield limit, but they may be given a higher yield limit and ultimate strength values by cold work, e.g. by stretching.

In welding stainless steels one aims at obtaining a weld metal with a chemical composition and characteristics which correspond to those of steel both from a corrosion viewpoint and other viewpoints. If one welds ferrite-martensitic, ferrite-martensite-austenitic or martensite-austenitic steels with electrodes having an analysis identical to that of the steel the melted weld metal in an unannealed condition will have a high yield limit and ultimate strength but, on the other hand, a very insignificant elongation and impact value. By a subsequent heat treatment the elongation and impact value of the weld metal may be improved; however it has been very difficult to reach full conformity to the properties of the steel.

As regards welding, the elongation value of the weld metal may be regarded as a gauge of the weld's cracking resistance. When welding is carried out with electrodes which deposit a weld metal with too low elongation values the risk of contraction cracks in the weld is great. When welding ferrite-martensitic, ferrite-martensite-austenitic or martensite-austenitic steel with the corresponding electrodes one has therefore normally applied a method which implies both the pre-heating of the basic material and the stress-relieving of the welded structure in order to reduce the risk of cracks.

In addition to high strength certain new ferrite-martensite-austenitic steel also possesses an improved weldability, which means that pre-heating has to be applied very seldom. As an example one may mention that a steel with a low carbon content of the type 16% by weight chromium, 5% by weight nickel and 1% by weight molybdenum which after a double heat treatment obtains yield limit values over 80 kp/mm^2, an elongation of about 20% and an impact value over 7 kpm/cm^2. In welding this steel with previously known electrodes it has not been possible to obtain a weld metal which in an unannealed condition possesses the corresponding values. On the other hand the characteristics of the weld metal could be improved by a suitable heat treatment so that they on the whole correspond to those of the steel.

According to the present invention it is

possible without subsequent heat treatment to obtain a weld metal with a high yield limit and ultimate strength in combination with very good elongation and impact value by using an electrode which deposits a weld metal having the following composition, by weight: 0.01—0.05% carbon, 0.1—0.9% silicon, 0.5—4.5% manganese, 15.0—18.0% chromium, 4.5—7.5% nickel, 0.2—2.5% molybdenum, 0.02—0.12% nitrogen and 0.2—3.5% tungsten the remainder being iron apart from unavoidable impurities. The content of undesirable impurities, such as sulphur, phosphorus, copper, lead, etc. shall be as low as possible.

The alloying constituents of the weld metal are adapted mutually in such a way that the following two equations with the chromium equivalent (Cr_e) and the nickel equivalent (Ni_e) are satisfied:

Equation 1: $Cr_e + Ni_e = \geq 26.0$ and ≤ 32.0
Equation 2: $1.4 \times Cr_e - Ni_e = \geq 15.5$ and ≤ 20.0
where $Cr_e = \%\ Cr + \%\ Si + \%\ Mo + 0.5 \times \%\ W$; and
$Ni_e = \%\ Ni + 0.5 \times \%\ Mn + 30\ (\%\ C + \%\ N - 0.03)$.

A welding electrode which satisfies the prerequisites indicated above deposits a weld metal with a structure composed of ferrite, martensite and austenite. If these three structure elements are balanced against each other the weld metal, without subsequent heat treatment, obtains yield limit values of about 60 kp/mm^2 and ultimate strength values of about 82 kp/mm^2 while at the same time as the elongation is about 30% and the impact value over 10 kpm/cm^2 at room temperature. In addition one obtains a lowered transition temperature, so that the weld metal still at −70°C possesses impact values over 6 kpm/cm^2 and at temperatures about −100 to −110°C meets the impact value requirements which are normally specified for vessels under pressure.

The addition of tungsten to austenitic stainless electrodes is known although the effect achieved has not been described in greater detail. In the present invention tungsten acts as a kind of modulator which in combination with nickel, manganese and nitrogen gives the desired balance to the ratio between the martensite part and the ferrite plus austenite parts. According to the present invention the martensite part of the weld structure shall lie between 5 and 50% and the ferrite plus austenite parts between 50 and 95%.

Consequently the present invention relates to an electrode or a filler for joint-welding or built-up welding stainless steels, particularly steel with a ferrite-martensite-austenitic structure, e.g. steel of type 16% by weight Cr—5% by weight Ni—1% by weight Mo, as well as steel of a ferrite-martensitic or martensite-austenitic structure, e.g. steel of type 12—14% by weight Cr, 0—3% by weight Ni and 0—2% by weight Mo. In the process of welding with electrodes according to the present invention the weld metal in itself does not require any heat treatment after the welding in order to achieve maximum toughness. In certain cases, on the other hand, the basic material may require stress-relieving in order to eliminate welding stresses or in order to level out the hardness tops which the latter types of steel show in heat-affected zones close to the weld. With the electrode described it is also possible to carry out stress-relieving within the temperature range 550—700°C without causing the strength values of the weld metal to decrease to any great extent.

In addition the electrode is suitable for welding certain austenitic stainless steels, provided that the corrosion conditions to which the welded object is subjected, suit the weld metal of the electrode. The electrode is particularly suited for joint welding stainless steels of identical or almost identical composition containing at least 13% by weight chromium, and 3.5% by weight nickel; they are then merged by means of arc welding and melting of a coated or an uncoated electrode.

By hardfacing or deposit welding the electrode is also very suitable for coating a surface on work-pieces of unalloyed, low-alloyed or stainless steels; the hardfacing then takes place with coated or uncoated electrode of the invention.

The welding electrode according to the present invention may be made in the shape of coated electrodes or uncoated wire for melting in an inert protective gas atmosphere or under a protective blanket of granulated welding powder, so-called flux. The bare wire in its turn may be homogeneous or so-called pipewire.

The covering of coated manual-welding electrodes consists of fluxing material, arc-stabilizing, deoxidizing and alloying elements as well as some plasticizer for making the substance ductile. The composition of the covering may be varied and may have a lime-basic, rutile-basic or rutile-acid character all according to the welding properties desired. It is essential for this embodiment within the scope of the invention that the covering should contain a certain amount of one or several of the following alloying elements: chromium, nickel, molybdenum, tungsten, manganese, silicon and nitrogen, partly in order to compensate the loss by burning which normally occurs in connection with the transport of material through the arc and partly in order to provide the weld

with that part of the alloying elements which possibly for practical reasons has not been alloyed into the core wire.

According to the second embodiment, i.e. an uncoated filler wire for melting in an inert protective gas or under a protection blanket of granulated welding powder, the composition of the wire in the case mentioned first shall conform as nearly as possible to the desired weld analysis and in the latter case be adapted to the composition of the welding powder.

Examples of some differently coated electrodes and their characteristics are given below in Tables I and II:

TABLE I — Chemical Analysis

Element	Electrode B	C	D	E	F
Carbon weight %	0.026	0.029	0.028	0.028	0.024
Silicon weight %	0.74	0.68	0.54	0.64	0.38
Manganese weight %	2.42	3.40	2.72	3.32	3.14
Chromium weight %	16.6	16.3	16.1	17.1	15.9
Nickel weight %	5.6	6.1	7.0	5.9	6.2
Molybdenum weight %	1.16	1.45	1.72	1.09	1.29
Nitrogen weight %	0.101	0.082	0.060	0.099	0.097
Tungsten weight %	2.98	2.80	2.44	3.08	2.97
Chromium equivalent	20.0	19.8	19.6	20.4	19.1
Nickel equivalent	9.7	10.2	10.1	10.5	9.5
Value according to equation 1	29.7	30.0	29.7	30.9	27.6
Value according to equation 2	18.3	17.5	17.3	18.1	17.2

The chemical analysis has been made in the manner prescribed in different standards, e.g. DIN 8556, Blatt 2 (Deutsche Industrie Normen), i.e. one makes a weld on plate with a great number of beads and determines the chemical analysis of that part of the weld which is further than 10 mm from the plate. In doing so the effect of the basic material is eliminated.

TABLE II — Characteristics of strength

Characteristics	Electrode B	C	D	E	F1	F2
Yield limit, σ 0.2, kp/mm²	59	57	57	61	60	59
Ultimate strength, kp/mm²	77	76	77	80	80.5	80.5
Elongation, % 5 × d	27	30	29	30	31	32
Contraction %	34	45	48	41	49	50
Impact value, Charpy V						
kpm/cm² + 20°C	10.5	9.7	9.2	10.9	11.8	11.0
kpm/cm² − 70°C	—	—	—	—	6.7	4.5
Test condition	un-annealed	un-annealed	un-annealed	un-annealed	un-annealed	heat treated

The values indicated above represent an average of several tests. The welding tests have been carried out with a coated electrode in the manner prescribed in DIN 1913, Blatt 2. For the all-welded tensile tests, test specimens of type 10C50 according to SIS 1121 13 (SIS=The Swedish Standard Association) and for the impact tests Charpy V-notch specimen according to SIS 1123 511 have been used. The F2 test indicated above is heat-treated at 600°C with subsequent air-cooling.

WHAT WE CLAIM IS:—

1. A welding electrode for electric arc welding intended for joint welding and built-up welding stainless steels, particularly steels with a ferrite-martensitic, ferrite-martensite-austenitic or martensite-austenitic structure, characterized in that the electrode deposits a weld metal having the following composition by weight: 0.01—0.05% carbon, 0.1—0.9% silicon, 0.5—4.5% manganese, 15.0—18.0% molybdenum, 0.02—0.12% nitrogen and 0.2—3.5% tungsten, the remainder being iron apart from unavoidable impurities, the alloying constituents being adapted mutually in such a way that the following two equations with the chromium equivalent (Cr_e) and the nickel equivalent (Ni_e) are satisfied:

Equation 1: $Cr_e + Ni_e = \geq 26.0$ and ≤ 32.0
Equation 2: $1.4 \times Cr_e - Ni_e = \geq 15.0 \leq 20.0$
where Cr_e = % Cr + % Mo + % Si + 0.5 × % W; and
Ni_e = % Ni + 0.5 × % Mn + 30 (% C + % N − 0.03);

as a result the microstructure of the weld metal in a welded or heat treated condition contains martensite, ferrite and austenite of such a composition that the martensite part lies between 5 and 50% and the ferrite plus austenite parts between 50 and 95%.

2. A welding electrode according to Claim 1 substantially as herein described.

3. A process of merging stainless steels of identical or almost identical composition, containing at least 13% chromium and 3.5% nickel, characterized in that they are merged by means of arc welding and melting of a coated or uncoated electrode as claimed in Claim 1 or claim 2.

4. A process of coating a surface of workpieces of unalloyed, low-alloyed or stainless steels by means of hardfacing or deposit welding, characterized in that the hardfacing is carried out with a coated or an uncoated electrode as claimed in Claim 1 or Claim 2.

For the Applicant:
LLOYD WISE, BOULY & HAIGH,
Chartered Patent Agents.
Norman House,
105—109 Strand, London, W.C.2.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1971.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.